Lesson Plan

Fishing for a Living: How do we know what Albatrosses eat?

Focus
Seabird diet, plastics, migration, North Pacific

Focus Questions
How do we learn about seabirds?
How are seabirds indicators of the ocean's health?
What types of plastic are most dangerous to seabirds?

Learning Objective
1. Learn about what Black-footed Albatrosses (BFAL) and Laysan albatrosses (LYAL) eat
2. Learn about the conservation need and what scientists are learning through research
3. Examine, identify, and classify the contents of an albatross bolus
4. Learn about plastics, marine debris

Grade Level
7-12

Materials

1 Maps-see Appendix
2. Assorted plastics (have students collect)
3. Bolus photos (see CD)
4. Tub with salt water (optional for plastics activity)
5. Bolus Investigation Data Sheet (See Appendix)
6. Student Question Sheet (See Appendix)
7. Teacher Answer Guide (see Appendix)
8. Computer with powerpoint or internet browser

Audio Visual Materials

1. Albatross natural history slide show

Teaching Time
1-3 class sessions

Seating Arrangement
Flexible

Maximum Number of Students
30-35

Key Words
Albatross
Bolus
Forage
Longline Fishery
Pelagic
Exclusive Economic Zone (EEZ)
National Marine Sanctuaries

Background Information

SEABIRD FORAGING TECHNIQUES

Seabirds make their living from the marine environment; some are coastal and remain near-shore, while others, such as the albatrosses, spend much of their time at sea, far from land. Throughout their lives, albatrosses spend weeks (breeding season), months (post-breeding season), and even years (pre-breeding age) at sea. The open ocean may seem like a uniform environment to our untrained eyes, but for seabirds this is a complex habitat, where patchy prey distributions come and go in time and space. Some food is only seasonally abundant. Some food is too widely dispersed, and can only be harvested when it is concentrated in dense "packages". Seabirds consume prey at several **trophic levels** of the marine food web, ranging from zooplankton, to fish and squid. These upper levels obtain their energy from the phytoplankton (tiny plants at the base of the food web). Because seabirds use different niches, they feed in many different ways. Very broadly, they are either surface seizers, divers, or plungers. For example, coastal in-shore species such as gulls and terns gather to feed in areas where prey are abundant at the surface or are forced to the surface. Diving seabirds (e.g. penguins, **alcids, shearwaters**) are wing-propelled or foot-propelled divers capable of diving hundreds of feet to feed on food below the surface. The **pelagic** seabirds, such as the frigatebirds, storm petrels, and albatross soar over great expanses of the ocean surface in search of widely scattered prey available at the surface.

BLACK-FOOTED ALBATROSS

The Black-footed Albatross *Phoebastria nigripes* (BFAL) migrates, rests, and soars in search of food across vast regions of the North Pacific Ocean. This species breeds on islands in the Hawaiian Island chain, on Johnston atoll, and south off Japan, from late October to mid-June. Black-footed Albatross nest on low coral and sand islands, on open sandy beaches or dunes, and sometimes among vegetation. Egg laying occurs November – December, incubation lasts on average 65.5 days, and the one chick per pair hatches between January 15 and February 7, and fledges in mid-June. Males are slightly larger than females and have a longer bill; mate retention is high and pairs are highly **philopatric**. Although immature plumage is similar to adults, 1st year birds lack the white ring around the bill and white feathers at the base of the tail. Birds do not breed every year and the age at first breeding averages 7-8 years. Adult brooding chicks **forage** closer to the colonies (100s km); in contrast, while feeding chicks, birds make a round trip of over 7,000 km from the Northwestern

Hawaiian Islands to the productive waters off central California to find food for their chicks. Non-breeding birds disperse throughout the North Pacific between 20° and 58 ° N. Black-footed Albatross are opportunistic diurnal surface feeders that find food on the ocean surface to feed themselves and their young. They eat flying fish eggs, squid, crustaceans, fish, and pelagic barnacles, and take food by dipping and scavenging. They are frequently seen around fishing vessels where they scavenge on ship **offal** and bait.

Threats: There is great concern about the declining population of Black-footed Albatross **(the International Union for Conservation of Nature [IUCN]** has designated this species as "Endangered") largely due to fishery by-catch in **longline fisheries**. Additional threats are posed by plastic ingestion by adults and chicks. Seabirds are indicators of change in marine ecosystems and can highlight threats caused by increased human use of coastal and open-ocean ecosystems.

In particular, plastic marine debris affects many seabirds and other marine species (e.g. turtles, marine mammals); each has a unique vulnerability to marine pollution. Adult albatrosses, for instance mistake floating plastic debris for food, and ingest huge quantities of plastic bottle caps, discarded cigarette lighters, plastic toys, and broken plastic fragments. Unfortunately, these items are brought back and fed to chicks reared on remote islands, far away from where these pollutants enter the marine ecosystem.

SEABIRD RESEARCH: Much has been learned about the life of marine birds and about their ecology and conservation, including their predators, prey, and habitats on land. For example, we know where many key seabird breeding colonies are located, and how many birds breed there. However, because many species spend long periods of time at sea, out of sight of researchers working on bird colonies, seabirds have been difficult to study and understand. Therefore, we know relatively little about their foraging areas, particularly during the non-breeding season. Most at-sea surveys have been conducted around breeding and nesting sites or over vast oceanic regions. Unfortunately these surveys cannot determine the status (breeding/not breeding) or the gender of the birds sighted at sea. Moreover, because many seabirds fly over very large areas in search of food, it is difficult to interpret these sightings. Thus, ship-based surveys provide an incomplete picture of the ecology and the habitats of far-ranging seabirds.

Advances in Technology: Many advances in technology such as the use of light-

weight **satellite transmitters** has enabled scientists to learn much about the movement patterns of seabirds. Satellite telemetry, is being used to track daily, seasonal, and annual movements of birds at sea. This technology has greatly advanced our understanding about the ocean habitats seabirds use and about their interactions with commercial fisheries.

Example of a Current Research Project that uses satellite transmitters:
"Black-footed Albatross Post-Breeding Movement Study."
Using satellite technology, a group of marine ecologists initiated a study in 2004 to track movements of Black-footed Albatross to measure the potential overlap with locations of longline fishing activities during the post-breeding period.

Importance of Research: Science plays a key role in seabird conservation by providing resource managers with the critical information about basic biology, ecology, and movement patterns required for effective management decisions.

Why study seabird diet? Seabirds are indicators of change in marine ecosystems and diet studies can highlight shifts in prey types, abundance, and distribution as a result of large scale climate changes. Seabirds can also be used to quantify changes in the threats caused by increased human use of coastal and open-ocean ecosystems (e.g. plastic pollution).

Diet Study Methods: Much of what we know about the diets of seabirds has been learned from studies conducted at breeding colonies, where adults come to shore to breed and to provision their chicks. Thus most information on seabird diets and habitats emphasizes the breeding season. Knowledge about the movements, habitats, and prey of seabirds during the nonbreeding season is limited and requires further research. The following are some methods used.

- Examine stomach contents (can be biased if birds associated with fisheries are taken as bycatch, and due to differential digestibility of certain prey types e.g. squid beaks and fish otoliths are not readily digested because they are composed primarily of calcium carbonate; soft-bodied prey may go undetected in a diet sample)
- Catch birds and collect food samples (spontaneous or forced regurgitation)
- Collect prey samples dropped near nest sites (biased toward larger, more spiny, or deeper-bodied prey due to difficulties in handling or swallowing prey)
- Visually identify prey carried in the bill, usually during the delivery of prey by adults to chicks (prone to have the largest margin of error because it relies on remote observation; bias in prey identification is

another issue)

- Stable isotope analysis is a relatively recent method used to determine seabird diets and trophic relationships
- Some seabirds (e.g. albatrosses) retain un-digestible items in their stomach which are fed to their chicks when they return to their colony. Frequently, birds regurgitate a compact mass **(bolus)** that contains both "natural" (e.g., squid beaks) and "anthropogenic" (e.g. plastics) undigested items. Much information about seabird diet can be learned by studying the contents of these boluses.

GLOSSARY OF TERMS

Alcid: a colonial nesting seabird from the northern hemisphere, including species such as auklets, guillemots, murres, murrelets, and puffins.

Bolus: a regurgitated compact mass of recently ingested, largely undigested or undigestible items
regurgitated by albatrosses

Dichotomous Key: An organized way of classification based on physical characteristics; an identification tool that uses paired statements to assist a person in identifying an organism (e.g., flowers) or an object (e.g., rocks)

Exclusive Economic Zone (EEZ): U.S. Exclusive Economic Zone is the 200 nautical mile ocean region adjacent to the coast where the U.S. can manage and enforce fishing activities as well as exploration, exploitation, conservation, and management of natural resources found in this maritime zone.

Fledge: feed, care for, and rear young birds for flight; term used to describe chicks ready to leave the nest site

Forage: to search for food

International Union for Conservation of Nature (IUCN): The World Conservation Union is the world's largest and most important conservation network. The Union brings together 82 States, 111 government agencies, more than 800 non-governmental organizations (NGOs), and some 10,000 scientists and experts from 181 countries in a unique worldwide partnership.

Latitude: latitude describes the North – South position on the surface of the Earth, and is measured from the equator (latitude = 0) to the poles (latitude = 90), with positive values going north and negative values going south.

Longitude: longitude describes the east – west position on the surface of the Earth. Longitude is measured from the Prime Meridian (which is the longitude that runs through Greenwich, England) with positive values going east and negative values

going west.

Longline Fishery: a method of commercial fishing using sections of line baited with hooks that can be 150-400 m in length. The main lines can be several 10's of miles long (up to about 100 km for pelagic longlines)

Offal: waste parts of an animal e.g. fish entrails, heads, and tails

Pelagic: inhabiting the open ocean as distinct from shores and estuaries; also refers to animals, processes and habitats that occupy in the water column, as opposed to those that live in or on the seafloor (benthic)

Philopatric: " love of place"; the custom of returning from a distance to last year's breeding place.

Shearwater: a long-winged oceanic bird, which in flight skims close to the surface of the water

Taxonomic relationships: a relationship between taxon (a group or entity) that is associated with the orderly classification of species

Trophic level: the position of an organism or species in a food web, ranging from the primary producers (an organism that synthesizes material by photosynthesis or chemosynthesis) e.g. phytoplankton and plants (level = 1), primary-secondary and tertiary consumers (level 2-3, which feed on other organisms along that food web).

Preparation

Review slide shows and scripts and make sure you can open them. They are available in powerpoint and/or html to be played in an internet browser.

Pick out which activities/labs you want to do and prepare worksheets and materials for each. See Appendix for worksheets and maps referenced in activity outline.

Reproduce color maps/photos of boluses in color ink.

Reproduce bolus dissection data sheet and plastic dichotomous key worksheet

Learning Procedure

1. Introduce students to the Black-footed albatross natural history using CD provided with this activity packet. See albatross natural history.ppt on CD, use script to get familiar with slides. The show is also provided in html.

2. Introduce students to the Black-footed Albatross colonies, tagging location, and foraging ranges using Map #1. Relay some of the background information to your students as to the study's purpose. *Estimate how many kilometers a bird might travel from Japan/Hawaii to the tagging location.*

3. Using Map #2 (in color), have students examine the movements of nine satellite-tagged Black-footed Albatross across the North Pacific Ocean during July-October 2004. The black boundaries indicate the Exclusive Economic Zone (EEZ). Each colored line on the map represents a different individual bird. Have your students describe the trackline patterns they see e.g. 2 birds went to waters off Japan; 1 bird went north, just south of the Aleutian Islands; 1 bird went south, etc. Given this information, *how would you investigate albatross ocean habitats and potential threats to this endangered species. What would you like to know if you were trying to protect these birds?*

4. Use Map #3 to identify the locations (represented by open circles) of the Black-footed albatross within three central California National Marine Sanctuaries (Cordell Bank, Gulf of the Farallones, and Monterey Bay) during the 2004 tracking season. The labeled contour lines (in meters, i.e-200, 1000, 2000) represent isobaths (depth contours). *Ask students what is an isobath? How do you draw them? What do they tell you?*

Questions to think about:

1) Looking at the lines on the map, can you see any steep parts of the ocean? Can you see any parts of the ocean where depth changes more gradually? How can you tell? Can you locate any canyons in this map?

2) At what depth are albatrosses most often tracked to?
ANSWER: Most locations of albatross occurred between the 200-1000m isobaths. This is a region of high bathymetric relief and is a very steep region known as the continental slope.

3) What might explain albatross associations with this specific water depth?
ANSWER: The prey that albatrosses eat live in deeper waters, which migrate to the surface of the ocean at night or at certain times in their lifecycle. Albatrosses are surface feeders and are attracted to fishing vessels to eat offal (discarded fish).

5. Introduce Lab Activity 1 Bolus Investigations (see Appendiz) Students will investigate the contents of a bolus.
Option #1: teacher/students dissect bolus in small groups
Option #2: if bolus not available, use color photos of dissected boluses; examine in small groups Use Albatross Bolus Data Sheet to record results of investigations

6. Introduce Lab Activity 2: Plastic Investigations (see Appendix)
Students will create a summary of investigations of plastic found in boluses by developing a plastic dichotomous key.

Pre Lab Activity for students: have students bring in plastic they have collected at home, at the beach, in the parking lot, around school grounds, on the street, etc.

8. Use Map #4 to introduce students to the region of the ocean in which Black-footed Albatross could encounter plastic debris – the "plastic accumulation zone" also known (and labeled) as the "Eastern Garbage Patch".

Question: Of the 9 tracked albatross during 2004, how many tracks occurred in the Eastern Garbage Patch? What might be some reasons for albatross venturing into this part of the ocean? *(Possible answers: they were following wind patterns that directed them there; the ocean might have been calmer in this region making it easier to find surface prey)*

9. Now that students have learned about the natural history of the Black-footed albatross and know about where they go to feed and what they eat:
Use map #5 to identify the location of the North Pacific Gyre. North Pacific Currents move in a clockwise spiral, or gyre, which traps debris originating from the North Pacific rim. Floating debris accumulates in the "Eastern Garbage Patch" where debris accumulates due to the Gyre.

- How do we know this?
- Think about how you would sample the ocean to measure debris.
- Would you use the same approach to sample for plankton? Why/why not?

NOTE: The region on the map labeled "Study Area" is the location where the private *Research Vessel Alguita* conducted surveys and identified the "Eastern Garbage Patch."

Visit these web-sites to learn more about ocean currents:
http://oceancurrents.rsmas.miami.edu/
or
http://seawifs.gsfc.nasa.gov/OCEAN_PLANET/HTML/oceanography_currents_2.html

Investigate why the North Pacific Gyre rotates in a clockwise direction. Hint: think about the wind patterns.

10) Use map #6 to further the students' understanding how currents carry plastic and other marine debris around the North Pacific; Heavy lines indicate average drift path; small arrows indicate local currents; dots indicate "Eastern Garbage Patch". Currents carry drifting debris along the heavy lines around the Subpolar Gyre (3 years), and around the Subtropical Gyre (6 years). Debris stays in Garbage Patch for about 50 years.

Use Maps 5 & 6 to answer the question: How does plastic get into the ocean and accumulate in certain regions?

10. Use Map 7 to review. Have students label the National Marine Sanctuaries in the Eastern Pacific (and the Papahanaumokuakea Marine National Monument). Have Students draw and label currents of North and Eastern Pacific Ocean, the approximate location for the Eastern Garbage Patch, the Tagging Area for 2004 BFAL study, and the breeding area in the Northwestern Hawaiian islands.

11. Use Student Question Sheet to summarize lessons and lab activities.

The "ME" Connection

What types of plastic are being found in albatrosses?
Did any of the items in the bolus look familiar?
Did any of the trash you picked up prior to creating the plastic dichotomous key look familiar? Could that trash potentially hurt marine ife?
Where does it come from?
How can I reduce the opportunity for plastic to make it to the ocean?

Connections To Other Subjects

Geography, ecology, biology, environmental science

Evaluation

Use student question sheet in appendix and pick out selected questions based on activities you do. See Teacher Answer guide for answers.

Resources

Oikonos Ecosystem Knowledge Black-footed albatross project
http://www.oikonos.org/projects/albatross.htm

Cordell Bank National Marine Sanctuary
http://www.cordellbank.noaa.gov

National Marine Sanctuary Program
http://www.sanctuaries.noaa.gov

Algalita Marine Research Foundation
http://www.algalita.org and alguita.com

International Migratory Bird Day
http://www.birdday.org

Pacific region's Migratory Birds and Habitat Program website
http://migratorybirds.pacific.fws.gov/

Pacific Seabird Group
http://www.pacificseabirdgroup.org/

US Fish and Wildlife Service at Midway
http://midway.fws.gov/

Great ocean currents website!
http://seawifs.gsfc.nasa.gov/OCEAN_PLANET/HTML/oceanography_currents_2.html
http://oceancurrents.rsmas.miami.edu/
Comprehensive Plastic website:
http://www.earthresource.org/campaigns/capp/capp-overview.html

LONGLINE FISHERIES RESOURCES

Seabirds and longlines: www.abcbirds.org/policy/seabird_report.PDF
Seabird bycatch: www.wsg.washington.edu/publications/online/execsummary.pdf
Pelagic longlines: www.wpcouncil.org

MARINE DEBRIS RESOURCES

NOAA Marine Debris Program
www.marinedebris.noaa.gov

Global Marine Litter Information Gateway
http://www.marine-litter.gpa.unep.org

Beachcombers Alert
http://www.beachcombers.org/

Article: Trashed Across the Pacific Ocean, Plastics, Plastic Everywhere
http://www.mindfully.org/Plastic/Ocean/Moore-Trashed-PacificNov03.htm

Algalita Marine Research Foundation
http://www.alguita.com and
http://algalita.org

View an Albatross necropsy:
http://www.oceanslive.org/
(search under archived videos)

Plastic Debris Rivers to Sea
http://www.plasticdebris.org/

Global Marine Litter Information Gateway
http://www.marine-litter.gpa.unep.org/

I found a rubber duckie
http://www.ifoundaduck.com/

EXTENSION ACTIVITIES

These are recommended ideas to further the concepts introduced in the preceding activities

1) Demonstrate effects of wind and movements of plastics on surface waters by filling a basin with water, add assorted plastic, use fan or hair dryer to simulate wind conditions on surface of water and effects this energy source has on plastic accumulation along simulated fronts.

2) We have investigated the direct effects of plastic with the activities, a recommended extension is to research some of the indirect effects of plastic ingestion such as the absorption properties of plastic and the release of persistant organic pollutants (POPS) that include substances such as dioxin, PCB's, and DDT.

3) Have students create fake seabird boluses from a made-up seabird species with specific life-history traits (size, foraging

method, visual acuity) and record the rules used to do so. Groups trade their boluses and each group has to guess the rules used to generate the bolus using a dichotomous key. Use photos of Boluses as a guide.

5) Have students research the national marine sanctuaries, what are the roles they play in protecting marine ecosystems?

6) Investigate Plastic Debris, Rivers to Sea Conference Website at www.plasticdebris.org

7) Investigate and research history of consumer plastic

8) Investigate and research recycling plastic

9) Identify ways you can help seabirds and other wildlife affected by plastic

10) Keep a record of how much plastic you use in one day

11) Learn more about the Black-footed Albatross Research Project at www.oikonos.org

12) Participate in seabird science and adopt a seabird by using the animal tracking website Signals of Spring http://www.signalsofspring.net/aces and track Albatrosses in real-time using satellite technology

13) Conduct a plastic debris survey where you live, and document amount of user plastic vs. industrial plastic pollution

14) Watch "Our Synthetic Sea" produced by the Algalita Marine Research Foundation see preview at: www.algalita.org

15) List ways how you can help prevent plastic pollution

16) List ways how you can help reduce your use of plastic

National Science Education Standards

Unifying Concepts and Processes: Change, constancy and measurement

Life Science: Life cycles of organisms, organisms and Environments, populations and ecosystems, behavior of organisms

Personal and Social Perspectives: Changes in Environments, Populations, Resources, and Environments, Natural Resources, Environmental Quality, Nature and Human induced hazards, science and technology in local, national, and global challenges.

Science as Inquiry: understanding about scientific inquiry K-12

Ocean Literacy: Essential Principles and fundamental concepts:

5: The ocean supports a great diversity of life and ecosystems: F: Ocean habitats are defined by environmental factors.

6. The ocean and humans are inextricably interconnected: humans affect the ocean in a variety of ways.

For More Information

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Credit